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Studies on the Activity and Survival of some Phthiracaroid Mites (Acari: Cryptostigmata) at Different Relative Humidities

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With 2 figures in the text

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Contents

1. Introduction

Before it is possible to carry out detailed investigations into the feeding, life history, etc., of any animal or group of animals, it is necessary to know something of the conditions of temperature, atmospheric humidity, moisture content of the substratum and light intensity which these forms can tolerate. Information from such investigations would also help in the interpretation of field data and observations on the distribution of these organisms.

There appears to be little or no information on the survival of the Phthiracaroidea at different relative humidities, although it is believed that they are susceptible to low humidity. Riha (1951) showed that the species *Phthiracarus pulcherrimus* Lombardini and *P. globosus* Koch were very resistant to low humidity and remained alive for 90 hours at 10 °C in air dried over calcium chloride, whereas species of the genera *Hoploderma* and *Oribotritia* were very sensitive to low humidity and remained alive for only 12 hours under similar conditions. The effect of variation in relative humidity on certain other groups of soil mites has been recently investigated by Haq (1960), Haq and Hobart (in press), Wallwork (1960), Atalla (1961), Atalla and Hobart (in press) and also by Madge (1961a, b), (1964a, b, c).

There remain, however, many groups of soil mites for which there is no information available on their reactions to lowered relative humidity.

2. General Materials and Methods

Animals for these experiments were obtained during the winter months (i. e. October to March) by extracting litter on a large scale in a Tullgren apparatus. The three common species of Phthiracarid mites used in these experiments were as follows: —

1) Present address see page 287.

(1) *Steganacarus magnus* (Nic., 1855); Syn. *Hoploderma magnum* (Willmann, 1931)
(2) *Phthiracarus piger* (Scopoli, 1763 sensu Willmann, 1931)
(3) *Rhysotritia ardua* (C. L. Koch, 1841); Syn. *Oribotritia loricata* (Willmann, 1931).

These species were usually available in such numbers that it was not necessary to set up laboratory cultures. All mites used in these experiments were kept in small capsules containing moist filter paper and litter for at least 48 hours prior to their introduction into the humidity jars.

The apparatus used for the humidity survival experiments was the same as that described by Haq (1960), Haq and Hobart (in press). It consisted of a number of 2 lb. Kilner jars, each containing a perspex stand holding a number of perspex strips $^1/_8$″ thick in which were drilled ½″ holes. The latter were covered on the lower side by bolting silk and on the upper side was placed a microscope slide cover slip. Saturated solutions of the following salts were used to produce different constant humidities (Peterson 1944, O'Brien 1948).

	R. H.
Distilled water	100 %
Potassium dichromate	98 %
Potassium nitrate	95 %
Potassium chloride	86 %
Sodium nitrate	75 %
Potassium iodide	65 %
Calcium nitrate	55 %
Zinc nitrate	44 %
Calcium chloride (anhydrous)	33 %
Potassium acetate	22 %

The experiments were done at 19 °C and although the above values are accurate only at 22 °C, the differences were so slight that they can be discounted. The time taken for the apparatus to reach equilibrium was noted using cobalt thiocyanate paper and this was found to be about 2 hours for the jar and 4 hours for the cell.

At each humidity 120 *S. magnus*, and 60 each of *P. piger* and *R. ardua* were used, 10 individuals being introduced into each cell. *S. magnus* was submitted to each of the above humidities, but the reactions of the other two species were observed only down to 55 %. Separate experiments involving fresh specimens lasting 12 hours and 72 hours were carried out on each species at each humidity. In the 12 hour experiment, the number of active mites was noted, not only at the end of the experiment, but also at 3, 6, and 9 hours, while in the 72 hour experiment, the numbers of active mites were noted at intervals of 12 hours. Active mites were taken to be those engaged in active locomotion at the time of observation. Inactive mites were taken to be those in which the legs were withdrawn, and the propodosoma was closed up against the hysterosoma, the whole resembling a spherical plant seed. Individual mites whose legs were still extended but which were not engaged in active locomotion at the time of observation were also considered as inactive.

3. Results

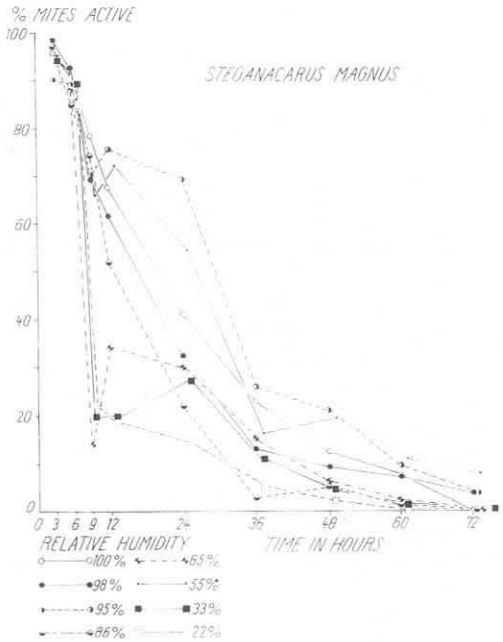
3.1. Numbers of active mites

The numbers of active mites for each species at each humidity were plotted separately as a percentage (fig. 1).

S. magnus showed a gradual decrease with time in numbers of active mites and this became more pronounced the lower the relative humidity used. After 12 hours exposure at 22 % R. H. 80 % (S. E. ± 0.31) of the mites were inactive. At the lower humidities almost all the mites were immobile after 48 hours exposure. At 100 % R. H. all the mites were inactive after 72 hours exposure, but at 55 % R. H. approximately 10 % (S. E. ± 0.19) of the mites were still active.

P. piger behaved similarly to *S. magnus*, and once again the numbers of active mites gradually decreased over the first 12 hours even at saturation. Thereafter the numbers of active mites decreased rapidly, and approximately 95 % (S. E. ± 0.11) of the mites were inactive after 36 hours exposure at all humidities, including 100 % R. H. At the lower humidities (65 % and 55 % R. H.) most individuals of *P. piger* became inactive very rapidly, and 90 % (S. E. ± 0.30) of the individuals of this species were inactivated after only 12 hours exposure at 55 % R. H.

R. ardua behaved similarly to the other two Phthiracarids, but the decrease in numbers of active mites was not so rapid as in *P. piger*. After 36 hours at 100% R. H., 80% (S. E. ± 0.47), and after 12 hours at 55% R. H., 50% (S. E. ± 0.86) of the individuals



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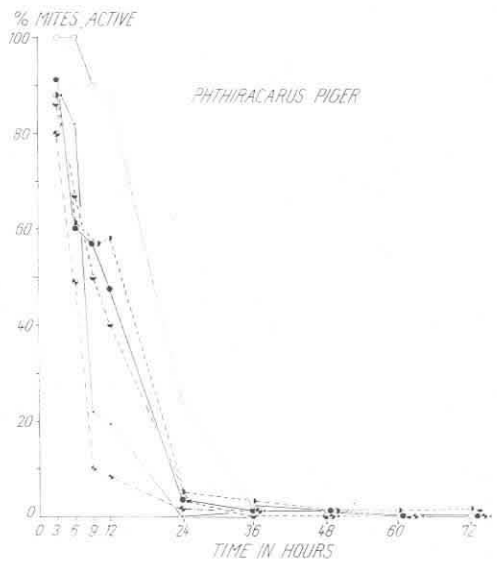

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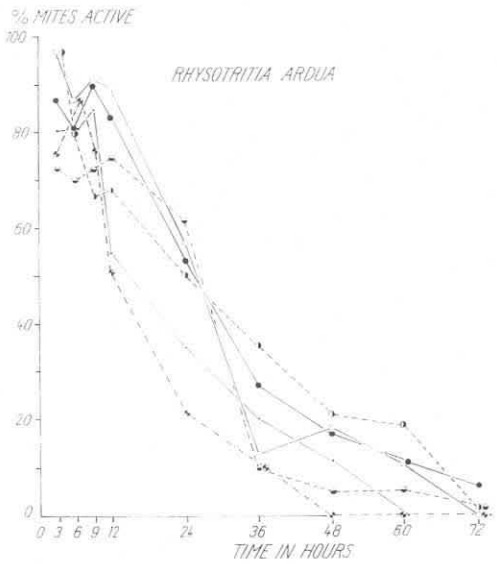

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Fig. 1. Numbers of active individuals of *Steganacarus magnus*, *Phthiracarus piger* and *Rhysotritia ardua* at various relative humidities after different periods of time.

of this species were inactive. The graphs of numbers of active *R. ardua* showed similar trends to those of *S. magnus*: even at saturation 100 % of *R. ardua* were inactive after 72 hours.

3.2. Mortality

At the end of both the 12-hour and 72-hour experiments the quiescent mites were transferred to cells containing moist filter paper, i. e. liquid water, for 12 hours. The numbers of mites which had resumed activity at the end of this period were recorded, and added to the number of mites still active at the end of the experiment, the total forming the percentage survival.

Fig. 2 shows the mean survival percentages of all three species of mites in both experiments. *S. magnus* showed only slight differences in survival between the two experiments (table 1). It is most interesting to note that the length of exposure seemed to have little effect upon mortality until 55 % R. H. was reached, for up to this point there was no marked decrease in survival. At 55 % R. H. and below, however, the survival decreased rapidly. Nevertheless, *S. magnus* is comparatively resistant to extremely low relative humidities, since nearly 20 % of the mites survived 72 hours exposure at 22 % R. H.

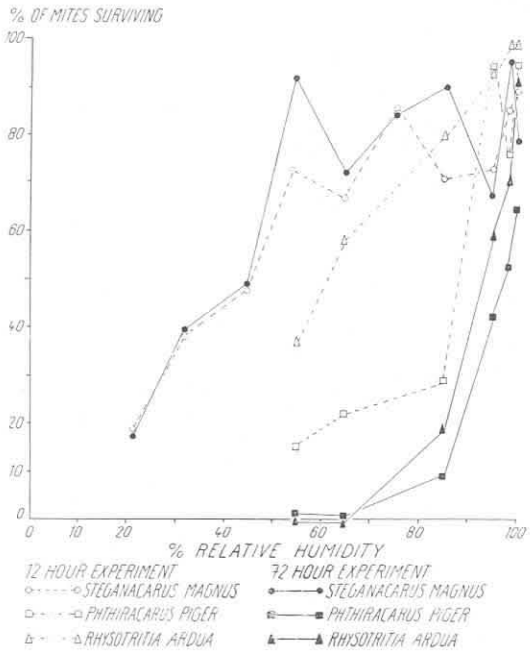

Fig. 2. Percentage survival of Phthiracaroid mites after exposure to different relative humidities.

P. piger was markedly less resistant to low relative humidities (table 1). In both the 12-hours and 72-hour experiments, the numbers of mites surviving decreased rapidly with decreasing relative humidity and 70 % of the mites were killed after only 12 hours exposure at 86 % R. H. Further, the longer time of exposure (72 hours) had a markedly adverse effect upon survival over the whole range of relative humidities used.

R. ardua behaved similarly to *P. piger* in that there are marked differences in survival between the 12-hour and 72-hour experiments. The decrease in survival was somewhat

Table 1 Relative (%) survival of Phthiracaroid mites (Mean and S. E.'s) at different relative humidities

	100% R. H.		86% R. H.		55% R. H.		22% R. H.	
	Mean	S. E.	Mean	S. E.	Mean	S. E.	Mean	S. E.
Steganacarus magnus								
12 hour expt.	88.3	**2.11**	70.0	**2.37**	73.3	**6.38**	18.3	**5.87**
72 hour expt.	68.3	**9.91**	90.0	**2.63**	93.3	**14.13**	18.3	**5.87**
Phthiracarus piger								
12 hour expt.	93.3	**3.27**	30.0	**7.83**	15.0	**3.64**	—	—
72 hour expt.	62.5	**7.37**	8.3	**2.86**	0.8	—	—	—
Rhysotri'ia ardua								
12 hour expt.	96.7	**0.71**	78.3	**2.44**	35.0	**5.30**	—	—
72 hour expt.	91.7	**2.44**	18.3	**2.44**	51.6	**3.78**	—	—

less rapid than in the latter species, and in the 12-hour experiment was spread evenly over the range 95% R. H. to 55% R. H. The anomalous behaviour of this species in the 72 hour experiment at 55% R. H. is unexplained (table 1).

4. Discussion

The results of these experiments suggest, perhaps, that the experimental conditions were not entirely ideal since there was a decrease in activity even at saturation. The reasons for this decrease in activity are not completely clear, but may be related to absence of food material, absence of water, insufficient touch stimulus, absence of light, to a percentage of the mites being quiescent for some of the time or finally, to the possibility that the initial activity is the result of disturbance. Recently, however, MADGE (1964b) has reported that the activity of certain other Oribatid mites tended to be greater at the commencement of humidity experiments. However, it is possible that the experimental conditions are not unfavourable, for the mortalities at the higher humidities are very low.

Since many of the mites revived and resumed activity in contact with liquid water, it is possible that the presence of liquid water together with touch stimulus is essential (RIHA 1951), and support is lent to this idea since the majority of mites were inactivated even at 100% R. H. It does seem, therefore, that the nature and moisture content of the walking surface may be very important. According to RIHA (1951) the Oribatidae lack the power to detect air moisture content, but more recently MADGE (1964a, b & c) has shown conclusively that certain Oribatid mites do possess this capacity. Nevertheless, under field conditions this would not normally be important since the soil atmosphere is usually saturated and therefore not limiting to activity. Under experimental conditions, however, the combined effect of the low moisture content of the substratum and the low atmospheric humidity would be very pronounced.

The results of the investigations on survival would appear to be at variance with the observations of RIHA (1951). Although this worker did not use *S. magnus* and *P. piger* in her investigations, she found that other species of *Phthiracarus* were quite resistant to low relative humidities, whereas species of *Hoploderma* were very susceptible. In the present investigation, *S. magnus* was found to be more resistant, whereas *P. piger* was much more susceptible. It seems unlikely that these species would behave differently from the remaining members of their respective genera, but RIHA (1951) did note that the humidity survival was greatest between 7 °C and 12 °C., and the fact that the present experiments were carried out at 19 °C may well be the reason for the different behaviour.

S. magnus was very resistant to humidities above 55% R. H., approximately 90% of the individuals surviving after 72 hours exposure to this humidity. Since the percentage

mortality of *P. piger* increased rapidly below 90 % R. H., it seems likely that this species can exist for only short periods of time in environments with relative humidities lower that 90 %. *R. ardua* behaved in a similar way to *P. piger*, but was somewhat more resistant to low relative humidities. It was clear from these experiments that the larger, darker *S. magnus* was markedly more resistant to low humidities than the smaller, more lightly armoured species *R. ardua* and *P. piger*.

5. Summary

An investigation into the activity and survival of three species of Phthiracaroid mites *Steganacarus magnus*, *Phthiracarus piger* and *Rhysotritia ardua* has been carried out. All three species were exposed to different relative humidities for 12 hours and for 72 hours. *S. magnus* was exposed to 22—100 % R. H., while both *P. piger* and *R. ardua* were exposed to the above humidities down to 55 % R. H.

All mites showed a decrease in numbers of active individuals with time and this number increased progressively the lower the relative humidity used. *S. magnus* was inactivated slowly, whereas *P. piger* and *R. ardua* were swiftly inactivated.

S. magnus was found to be quite resistant to low relative humidities. There was little change in the numbers of mites surviving down to 55 % R. H., but below this humidity, survival decreased rapidly. Both *P. piger* and *R. ardua* were very sensitive to low humidities and the longer time of survival (72 hours) had a markedly adverse effect upon survival over the whole range of relative humidities used.

5. Zusammenfassung

Es wurde eine Untersuchung über die Aktivität und das Überleben von drei Phthiracariden-Arten [*Steganacarus magnus* (Nic.), *Phthiracarus piger* (Scopoli) und *Rhysotritia ardua* (C. L. Koch); Acari, Oribatei] unter verschiedenen Feuchtigkeitsbedingungen durchgeführt. Tiere der drei genannten Arten wurden 12 bzw. 72 Stunden lang verschiedener relativer Feuchtigkeit ausgesetzt (*S. magnus* im Bereich von 22—100 und *P. piger* bzw. *R. ardua* von 55—100 % relativer Feuchtigkeit).

Alle Milben zeigten mit der Zeit eine Abnahme der Anzahl von aktiven Individuen und diese Zahl nahm fortschreitend ab, je geringer die gegebene Feuchtigkeit war. *Steganacarus magnus* wurde langsam, *Phthiracarus piger* und *Rhysotritia ardua* wurden dagegen geschwind inaktiviert.

Es wurde gefunden, daß *S. magnus* gegen niedere relative Feuchtigkeitsgrade ziemlich resistent ist. Bis zu einer relativen Feuchtigkeit von 55 % änderte sich die Zahl der überlebenden Exemplare dieser Art wenig, jedoch unterhalb dieser Feuchtigkeitsgrenze nahm die Anzahl der Überlebenden rapide ab. Die beiden anderen Arten, *P. piger* und *R. ardua*, waren gegen niedere Feuchtigkeit sehr empfindlich und längere Überdauerungszeiten (72 Std.) hatten eine auffallend nachteilige Wirkung auf das Überleben in der ganzen Reihe von verschiedenen relativen Feuchtigkeiten.

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